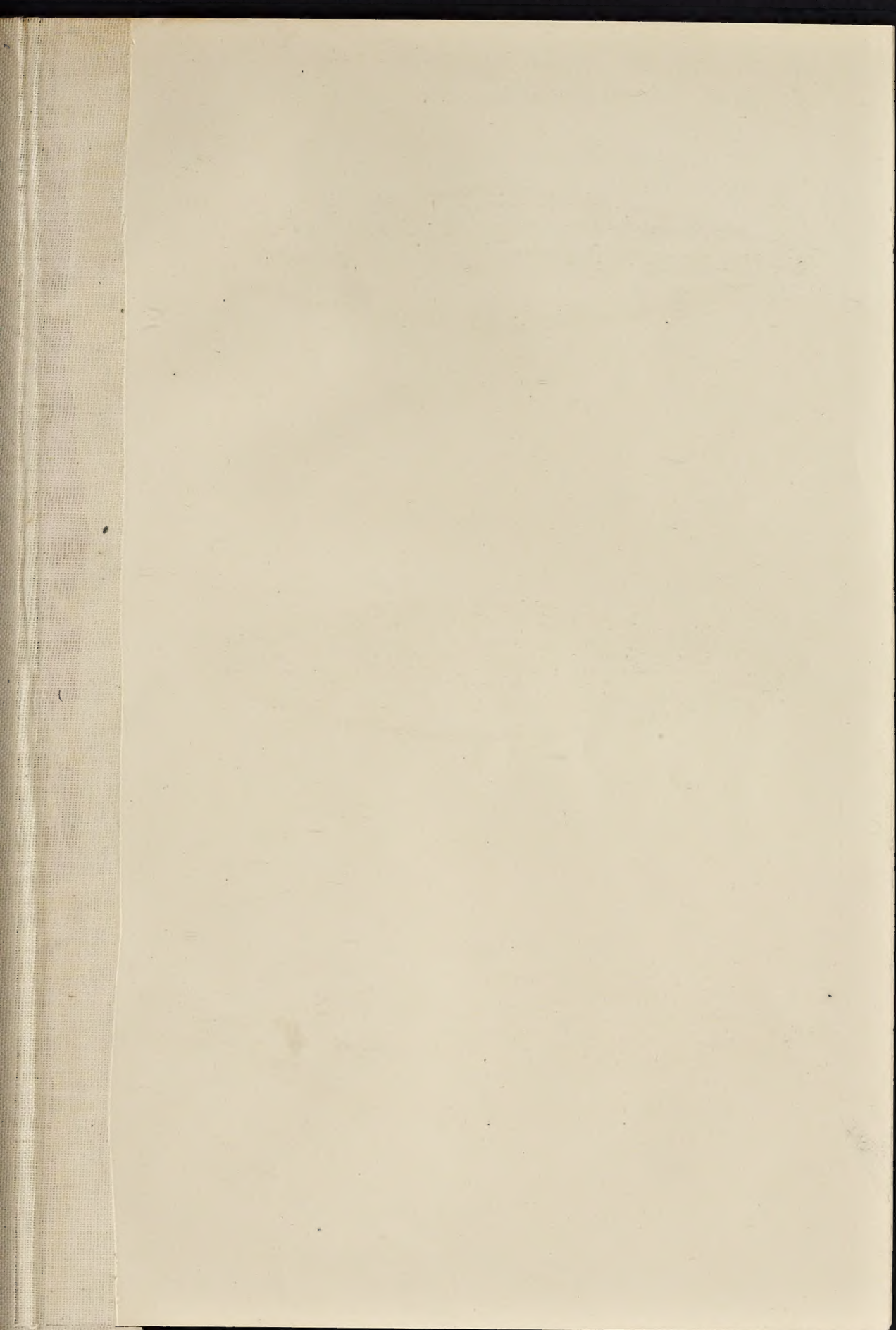


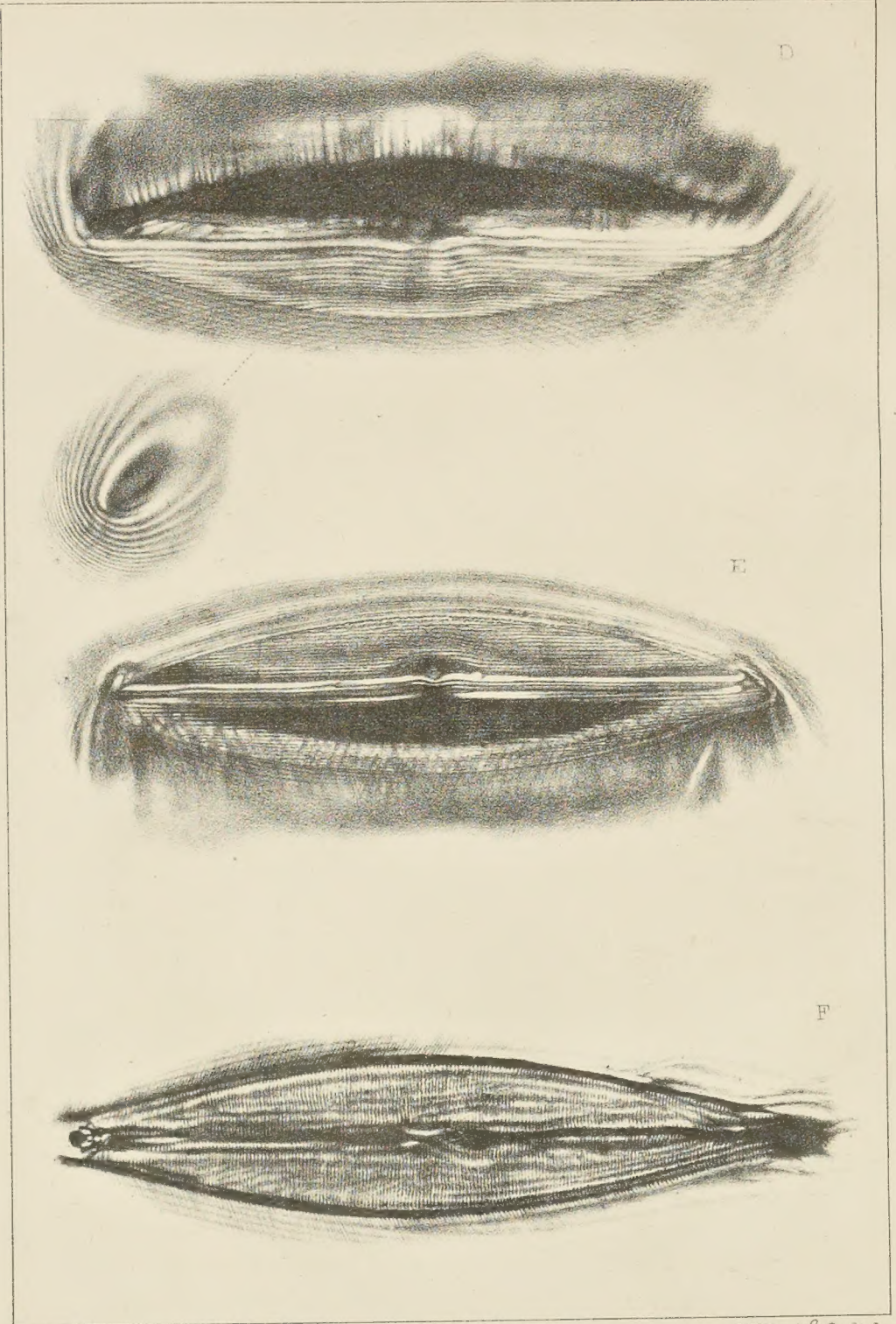
ARMY MEDICAL MUSEUM
—
PHOTO-MICROGRAPHS
OF
FRUSTULIA SAXONICA, NAVICULA RHOMBOIDES,
BODY SCALES OF THE MOSQUITO AND GNAT.
BY
SURGEON J. J. WOODWARD,
U. S. ARMY





13457





W. West & Co. lith.

The markings on *Frustulia Saxonica*.

II.—Note on the Markings of *Frustulia Saxonica*.

By Assistant-Surgeon J. J. WOODWARD, U. S. Army.

(Read before the ROYAL MICROSCOPICAL SOCIETY, November 3, 1875.)

PLATES CXXIV. AND CXXV.

ON returning from my last summer's vacation my attention was directed a few days ago, for the first time, to a letter by Mr. W. J. Hickie in the July number of the 'Monthly Microscopical Journal' (p. 32), on the subject of the markings of *Frustulia Saxonica*, which seems to call for some comments from me.

Mr. Hickie refers to a paragraph in the 'Monthly Microscopical Journal' (vol. ix., p. 86) headed "*Frustulia Saxonica* as a Definition Test," which he, however, thinks may possibly misrepresent my views, and remarks—"What is there said is by no means very clear; but it certainly does make him assert one of two things: either (1) that *Frustulia Saxonica* is a one-lined object (i. e. has transverse, but no longitudinal lines); or (2) that, though it undoubtedly has transverse, and may possibly have longitudinal lines as well, no one as yet has succeeded in seeing the latter, but that those who fancied they saw them, as Dippel and others, have been deceived by 'diffraction phenomena.'" I will frankly say that the second of these views very fairly represents my opinions on this subject, although it is not precisely what I said.

The paragraph quoted by Mr. Hickie is abridged from a "Note on the *Frustulia Saxonica* as a Test of High-Power Definition," which I published in the 'Lens' for October, 1872 (p. 233), and of which I send herewith two copies, with the request that one of them may be forwarded to Mr. Hickie. The original article was illustrated by a Woodburytype plate, of which I have now no spare copies; I send, however, two silver prints (marked A) from the negative used in its preparation. In this "Note" I quoted Dippel's description,* which attributes to *Frustulia Saxonica* both longitudinal and transverse striæ, and estimates the first at 18 to 20, the second at 34 to 35 in the one hundredth of a millimeter. I stated that I myself found the transverse striæ count 85 to 90 in the one thousandth of an inch, which agrees substantially with Dippel's figures, but said, "The longitudinal striæ of Dippel, however, I must regard as diffraction phenomena," and went on to assert that as I observed them "they varied too much in their distance apart, with varying obliquity of illumination, to bear any other interpretation." It will be observed that I did not, in my

* From 'Das Mikroskop und seine Anwendung.' Erster Theil. Braunschweig, 1867, s. 132.

"Note," speak generally, as Mr. Hickie does, of what "Dippel and others" fancied they saw, but specifically of the longitudinal striæ of Dippel. My reason for this limitation was, I confess, that I did not at the time know that any authority but Dippel had described longitudinal striæ on this diatom. So far as Dippel was concerned, I had not merely his description and his statement of the number of lines he observed to the inch, but the excellent and truthful woodcut in his book* on which to form an opinion. This woodcut, moreover, enabled me both then and now to know that the specimens I studied belonged to the same species as that which Dippel described.

In my "Note," then, I spoke only of the *longitudinal striæ of Dippel*, but now, in response to Mr. Hickie's letter, I willingly express my belief that the longitudinal lines which he describes are of the same character. At the same time I shall be very glad if he can convince me, by satisfactory evidence, that this belief is erroneous, for analogy inclines me towards the opinion that in both *Frustulia Saxonica* and *Amphipleura pellucida* the striæ are really rows of beads, as is so easily to be seen in *Navicula rhomboides*, and that, consequently, we ought to be able to see longitudinal striæ when the illuminating pencil has the proper direction, if only our glasses had the requisite defining power.

In favour of his opinion that he has actually seen these longitudinal striæ on *Frustulia Saxonica*, Mr. Hickie states, in the first place, that Herr Seibert showed him in the summer of 1872 "a couple of very beautiful photographs of that diatom, one of which exhibited the transverse, and the other the longitudinal lines, with far more clearness, sharpness, and distinctness than the printer will be able to reproduce the words I have here written." If I had these photographs before me, they might, perhaps, though I confess I do not expect it, show me that Herr Seibert has seen something I have been unable to see, and I must therefore express the hope that Mr. Hickie, in return for the package of photographs I send him herewith, will take the trouble to obtain copies of them for me to study. I hope also that he will obtain copies of them for the Royal Microscopical Society, to compare with those I send. In the absence of Herr Seibert's photographs, however, I would remark, that spurious lines, due to diffraction and interference, can be photographed quite as readily as real lines, from which they can only be distinguished by observing precautions which Mr. Hickie's letter does not show to have been considered either by himself or any of the distinguished gentlemen to whom he tells us he exhibited the longitudinal striæ in question.

Mr. Hickie tells us further, that "In Rhomboides also the transverse lines are much closer than the longitudinal, whereas in

* *Op. cit.*, fig. 103.

Frustulia Saxonica it is just the reverse." This statement directly contradicts the description of Dippel, whose measurements, quoted above, make the longitudinal lines nearly twice as coarse as the transverse instead of finer, and it might at first be thought that the two gentlemen were describing different things, but, in point of fact, as I stated in my "Note," these spurious longitudinal lines vary greatly "in their distances apart with varying obliquity of illumination," and also, I may now add, with varying positions of the fine adjustment, so that I have had no difficulty in photographing them, as seen on the same frustule, and with the same objective and distance, both finer than the transverse ones as described by Mr. Hickie, and coarser than the transverse ones as described by Dippel, and in both cases they appeared to me, as Mr. Hickie says they did to him, "as plainly and visibly as any of us are ever likely to see our own faces in our looking-glasses." The distinctness with which these lines can be seen has nothing to do with the question of their objective reality, for diffraction phenomena are often quite as distinctly visible as the optical images of actual objects.

The question of the real nature of these longitudinal lines appears to me to be one of considerable interest, because it brings up the matter of recognizing lines due to diffraction and interference, when observed in the field of the microscope, and because these phenomena have been a fruitful source of error in the interpretation of microscopic images. I have therefore thought it worth while to prepare a series of photographs of *Frustulia Saxonica* for the purpose of illustrating my meaning.

The first of these photographs (marked B) represents a frustule of *Frustulia Saxonica* adjusted to show the transverse striæ. This frustule measured $\frac{1}{500}$ of an inch in length, with eighty-six striæ to the $\frac{1}{1000}$ of an inch. The negative is magnified 1830 diameters very nearly, and to this of course the paper print closely approximates.*

The second photograph (marked C) represents the same frustule with its left end raised so as to bring it obliquely to the light. In its lower half, besides the transverse lines, a series of longitudinal lines can be seen, which give rise in places to a distinct appearance of dots at their intersections with the transverse striæ. The nature of these lines will be best understood after a study of the third and fourth photographs.

In the third photograph (marked D) the same frustule is shown with its left-hand angle still more elevated. The transverse striæ have disappeared; but in the left-hand half of the frustule we have a beautiful series of longitudinal lines which very closely resemble

* Silver prints after mounting are usually a trifle larger than the negatives from which they are printed.

those shown in Dippel's woodcut above referred to. Such longitudinal lines as these, I suppose, Mr. Hickie himself has observed and recognized as spurious, for he says in his letter—"I had also no difficulty in bringing into view those wide-spaced, spurious lines alluded to by Dr. Woodward."

Let us observe the character of these lines. They run parallel to the midrib, handsomely following its sweeping curves, and it will be seen that they become progressively closer and closer together from the midrib towards the margin of the frustule. It will also be seen that they do not terminate at the edges of the frustule, but sweep off into the open space outside, where they form a series of rhombic figures by crossing a fresh series of diffraction lines conditioned by the margin of the frustule, as the former series was by the midrib. These characters would be sufficient to show these lines to be spurious, but if, now, the fine adjustment be toyed with, or the illumination changed, or both, they pass, by the most insensible transitions, into new combinations, one of which is shown in the next photograph. I would also call the attention of those who examine this photograph to three shadows on the left of the lower part of the frustule, which are cast by three out-of-focus fragments of dirt adhering to the under surface of the glass cover of the preparation. Each of these shadows is surrounded by a series of lines due to diffraction and interference. The lower two sets of these lines especially very closely resemble the longitudinal lines on the frustule in number, distance apart, distinctness, and general character.

In the fourth photograph (marked E) the same frustule is shown standing vertically with the light coming from the right side of the picture. On both sides of the frustule, but especially on the right side—the left being in shadow—there are a series of fine longitudinal lines, which I suppose to be similar to those Mr. Hickie has described. They are rather closer together than the transverse striæ (counting eleven, on the negative, in the space occupied on the negative of the photograph marked B, by ten of the transverse striæ), and their distance apart is more equable than is the case with the longitudinal lines in the last photograph. Still, if the paper print be examined with a hand-lens, I think it will be plainly seen, as can readily be measured on the negative, that the lines become progressively closer towards the margin, those nearest the midrib being farthest apart. It will also be seen, on both sides of the frustule, and especially at its upper end, that these longitudinal lines are not limited to the surface of the frustule, but pass off into space outside, where they cross a fresh series of beautiful diffraction lines conditioned by the margin of the frustule. I would particularly invite attention to this last series of lines, especially as seen towards the top of the right-hand margin of the frustule. The

fine longitudinal lines shown on the frustule in this photograph, then, like the coarse ones shown in the last, have all the characters of diffraction fringes; but if any doubt remains, it is only necessary to toy with the fine adjustment, when the number of the lines and their distance apart will be found to vary continually, while in the case of the transverse striæ, or of any other real lines, the number remains constant as long as they can be seen at all.

Besides the principal frustule shown in these pictures, part of another frustule is shown in each, which affords still further illustrations of the longitudinal lines in question. I may add that, although I endeavoured to take the four pictures with the same power, trifling differences exist due to the necessary variations in the focal adjustment.

As a still further illustration of the spurious longitudinal lines of this diatom, I add a print (marked F) of a negative magnified 1600 diameters, made November 10, 1872, by Tolles's immersion $\frac{1}{8}$ th, in which the central frustule shows the transverse striæ, while portions of two others exhibit longitudinal lines, similar, as I must suppose, to those Mr. Hickie sees. I would call attention on this print, and, indeed, on the two others (marked A and B) which show the transverse striæ, to a curious series of diffraction lines just outside of the margin of the frustule, which appear to be conditioned by the transverse striæ themselves. These spurious lines are at exactly the same distance apart as the transverse striæ, but form a sharp angle with them.

I send copies of all these photographs for Mr. Hickie, and also a set for the Royal Microscopical Society. If the longitudinal lines which Mr. Hickie sees are, as I suppose, similar to those which I have photographed, these pictures will enable those who examine them to decide whether his interpretation or mine is correct. If he thinks he sees something of a different nature, I shall be happy to consider the evidence on that head when he presents it.

These photographs will, moreover, enable those interested in the subject to decide another question raised by Mr. Hickie in his letter, viz. whether what I have photographed and described is really *Frustulia Saxonica*, and also, whether I have, as he suggests, "merely been wasting" my "time on a bad slide." It is quite true that I have been using Möller's slides; it is also quite true that, like Möller, I suppose *Frustulia Saxonica* to be identical with *Navicula crassinervis*. I do not pretend to any special personal knowledge of the proper classification of the diatoms, and derive my opinion entirely from my friend Professor Hamilton L. Smith, of Hobart College, Geneva, New York, who I suppose to be more thoroughly acquainted with the subject of the Diatomaceæ than anyone on this side of the Atlantic, and who wrote me, January 9, 1872: "*Navicula crassinervis* has long been recognized as =

Frustulia Saxonica." Mr. Hickie asserts that there is a difference, but does not make clear in what the difference consists. I should be happy to learn further from him on this head, if he has anything to teach. If, on examining my photographs, he thinks they represent something different from his slides of *Frustulia Saxonica*, I should be glad to receive one of these from him to study. I have the less hesitation in asking this favour, as he tells us his collection of these slides is a very extensive one.

I conclude these remarks with the hope that Mr. Hickie will find them as courteous as I acknowledge his own to be.

List of Photographic Prints accompanying Dr. Woodward's "Note on the Markings of Frustulia Saxonica."

- A.—Print from the negative used to illustrate Dr. Woodward's paper in the 'Lens,' $\times 1750$ diam.
- B.—Frustule photographed for the present paper to show the transverse striæ, $\times 1830$ diameters.
- C.—Same frustule, same power, showing both transverse and longitudinal lines.
- D.—Same frustule, same power, showing the longitudinal lines of Dippel.
- E.—Same frustule, same power, showing longitudinal lines similar to those described by Mr. Hickie.
- F.—Print from a negative made in 1872, showing the transverse striæ on one frustule, and longitudinal lines on parts of others.

EXPLANATION OF PLATES CXXIV. AND CXXV.

These Plates contain figures the same size as those in the several admirable photographs which Dr. Woodward transmitted to us. The various figures are given in the same order—A, B, C, &c.—as those above. Whereas, however, in the photographs more than one diatom is occasionally introduced, in the Plate but a single frustule is represented.

[The following remarks are contained in the 'Lens,' October, 1872.]

Note on the Frustulia Saxonica as a Test of High-Power Definition.

The genus *Frustulia* (Agardh) includes several species of diatoms which possess bacillar or navicular frustules, "immersed in an amorphous gelatinous substance."* The species are divided by Pritchard into two groups, the first with "evident striæ," while in the second the striæ are "wanting or very indistinct." In the second group Pritchard places the species *Saxonica* (Rabenhorst), so called from having first been noticed in Saxony, where it "forms dirty, olive-brown, tremulous jelly-like masses in little cavities of damp rocks." The 'Micrographic Dictionary' (second edition)

* 'A History of Infusoria.' By Andrew Pritchard. 4th edit., London, 1861, p. 924.

gives a brief description of this species, but does not mention the striae.

The first description of the striae with which I am acquainted was given by Professor Reinicke,* who saw fine transverse lines, but found no objective capable of bringing them out clearly enough to count them (He used immersion objectives of Hartnack.)

The markings on the *Frustulia Saxonica* are described and figured by Dippel,† whose description is as follows: "The *Frustulia Saxonica* possesses longitudinal and transverse striae, of which the first are tolerably far apart (from eighteen to twenty to the hundredth of a millimeter), the latter, on the contrary, somewhat closer than those of *Grammatophora subtilissima* (from thirty-four to thirty-five to the hundredth of a millimeter). Both systems of striae are very pale (*schwach gezeichnet*), so they certainly require an excellent objective for their resolution. Nevertheless, with oblique light, and on bright days, they can be seen with objectives of the highest power almost as well as those of the *Grammatophora*, if the object is only properly prepared, the valves separated (*gespalten*), and mounted dry. In balsam, on the other hand, the transverse striae are very difficult to see: nevertheless, I have recognized them, even in this case, with the System No. 10 of Hartnack."

During the summer of 1871, a slide of *Frustulia Saxonica*, mounted dry, was presented to the Museum by Dr. J. J. Higgins, of New York, and subsequently two other slides, also dry, were obtained from J. D. Möller, of Wedel, Holstein. I found no difficulty, on these slides, in seeing and counting the transverse striae, both with monochromatic sunlight and with the light of a small coal-oil lamp. The longitudinal striae of Dippel, however, I must regard as diffraction phenomena, similar in character to the longitudinal lines which some have described in the central portion of *Grammatophora* frustules; they varied too much in their distance apart, with varying obliquity of illumination, to bear any other interpretation. The transverse striae, on the other hand, I found very definite in character. I counted on different frustules from eighty-five to ninety to the thousandth of an inch, which agrees substantially with the results of Dippel, whose figures correspond to from eighty-six to eighty-nine to the thousandth of an inch. The frustules themselves varied in length from .0018 to .0029 inch.

I subsequently removed the cover of one of the dry slides obtained from Möller with the diatoms adherent to it, and

* See a review of his "Beiträge zur neuern Mikroskopie," in the 'Quarterly Journal of Microscopical Science,' vol. ii., new series, 1862, p. 292.

† 'Das Mikroskop und seine Anwendung.' Erster Theil. Braunschweig, 1867, p. 132.

mounted the specimen in Canada balsam. The striæ were then paler than before, but I cannot say that I found them more difficult to resolve. Both in balsam and dry I could get resolution by the Tolles's immersion $\frac{1}{6}$ th belonging to the Museum, and that by lamplight as well as by monochromatic sunlight. With immersion objectives of higher powers the lines were still more distinctly separated, and I obtained the finest results with the immersion front of the $\frac{1}{16}$ th of Powell and Lealand, and with the new immersion $\frac{1}{18}$ th recently made for the Museum by Mr. Tolles.

On the whole, the *Frustulia Saxonica* is an easier test than the *Amphipleura pellucida*, as may be inferred from the above measurement of its striæ, and the difference is especially marked by lamplight. Those therefore who work by lamplight only will find this test more extensively useful than the *Amphipleura*.

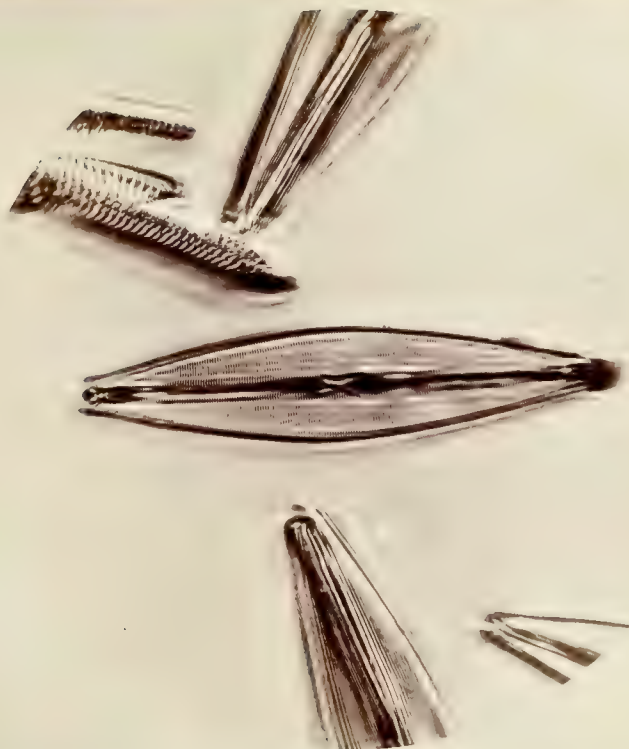
The Woodbury print [see Plate CXXIV., Fig. A] illustrating this article is copied from a negative made by the immersion front of the Powell and Lealand $\frac{1}{16}$ th belonging to the Museum. The power used was 1750 diameters. It displays the transverse striæ as seen when the utmost pains are taken to avoid the longitudinal diffraction lines.



Sarcocolla Saxonica.

1750

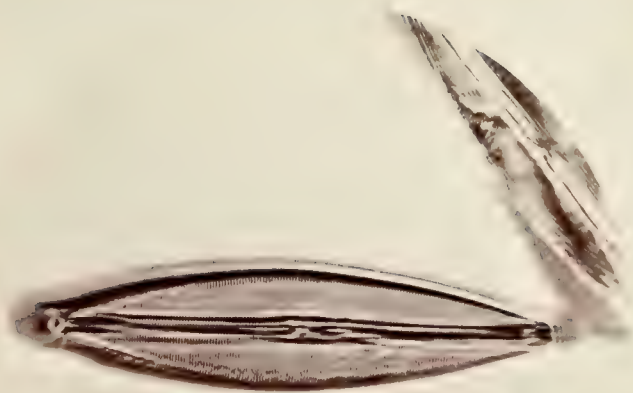
Howell & Ledland 46 in.
580



Prastulia Saxonica.
(Balsam.)

1600

Sollis's 78th m.
645



Australis Saxouca.

1830

Proell & Lealand's 76th in.
769



Saxonia Saxonica,
 Arranged to show spurious longitudinal lines.

1830

Dollé's 18th m.
 761





SEE OBSERVATIONS

Frustulia Saxonica.

Same, in a different position of focus, to show other
spurious lines.

1830

Tolles 75th in
762



PLATE XXXIII

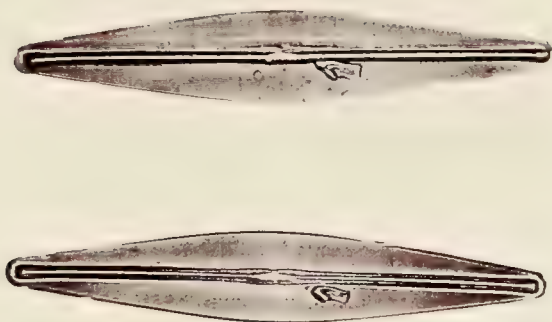
Foristulic baxenica

Arranged obliquely to show two sets of lines.

1880

Tollis's $\frac{1}{8}$ " $\frac{1}{60}$ in.





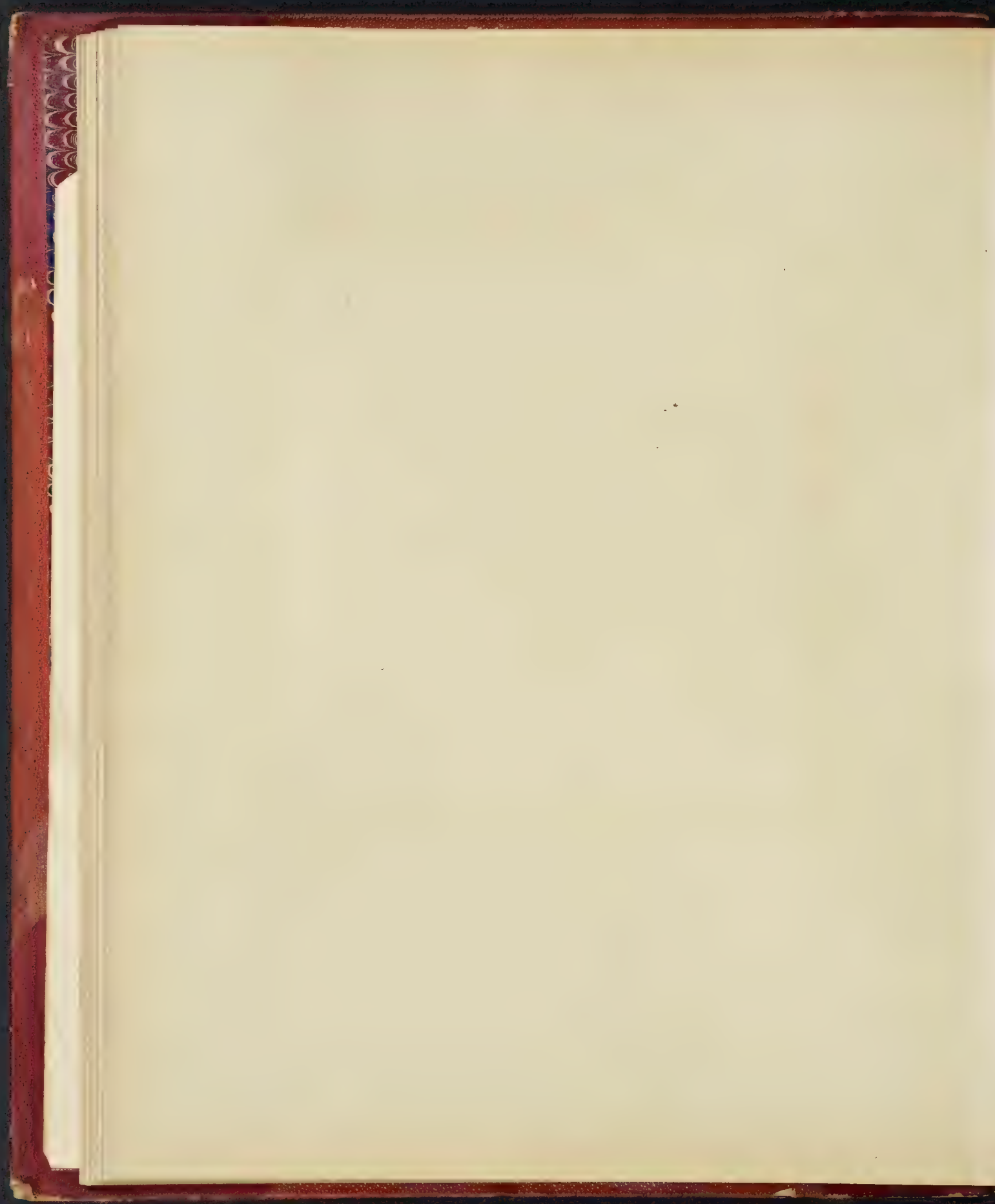
Fac simile of Herr Seiber's photograph of Frustulia Saxosina.
(Undoubtedly Navicula Rhomboides.)



Navicula rhomboides, (to show transverse lines.)
 (From Mollers Type-plate.)

580

Hartnack's No. 18 eni.
 793

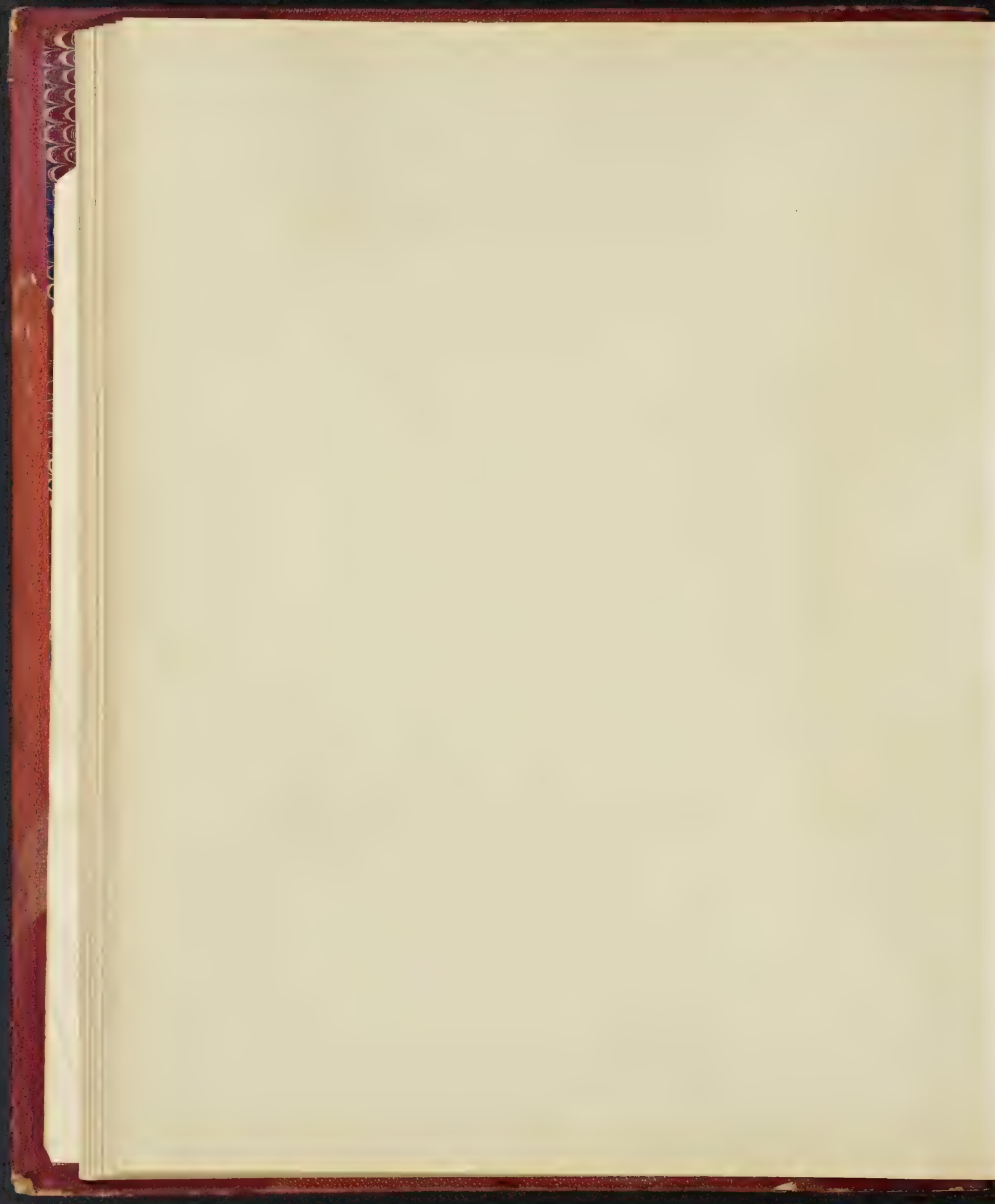




Ventricula rhomboides. (showing longitudinal view.)
(From Moller's Type-plate.)

580

Hartnack's No. IX.
794

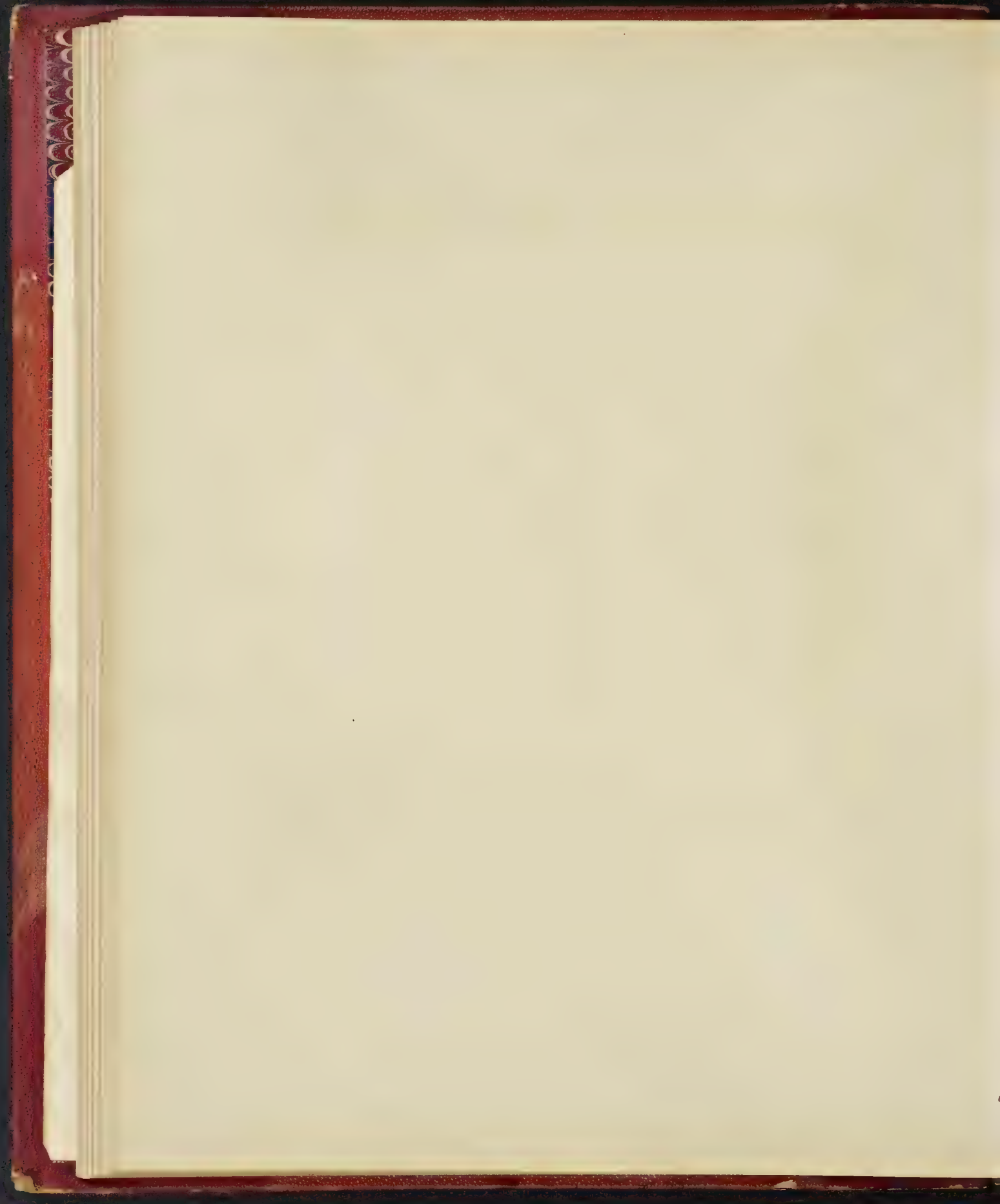




Naucicula Rhomboidea, showing beads,
From Moller's Type-plate.

870

Hartnack's No. 1X
 745





Navicula Rhomboides.

1550

Powell & Lealand's $\frac{1}{16}$ " in.
787

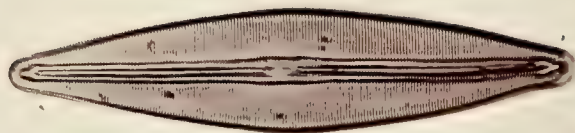


Navicula Rhomboides.

2700

P. & Ls $\frac{1}{16}$ " with ap. piece.
789



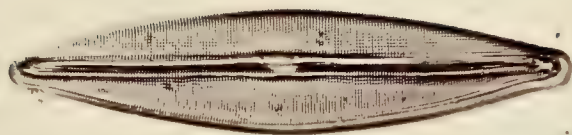


Navicula Rhomboides, (to show lines,
(Bennet's date.)

1700

Powell & Lealand to ems
813

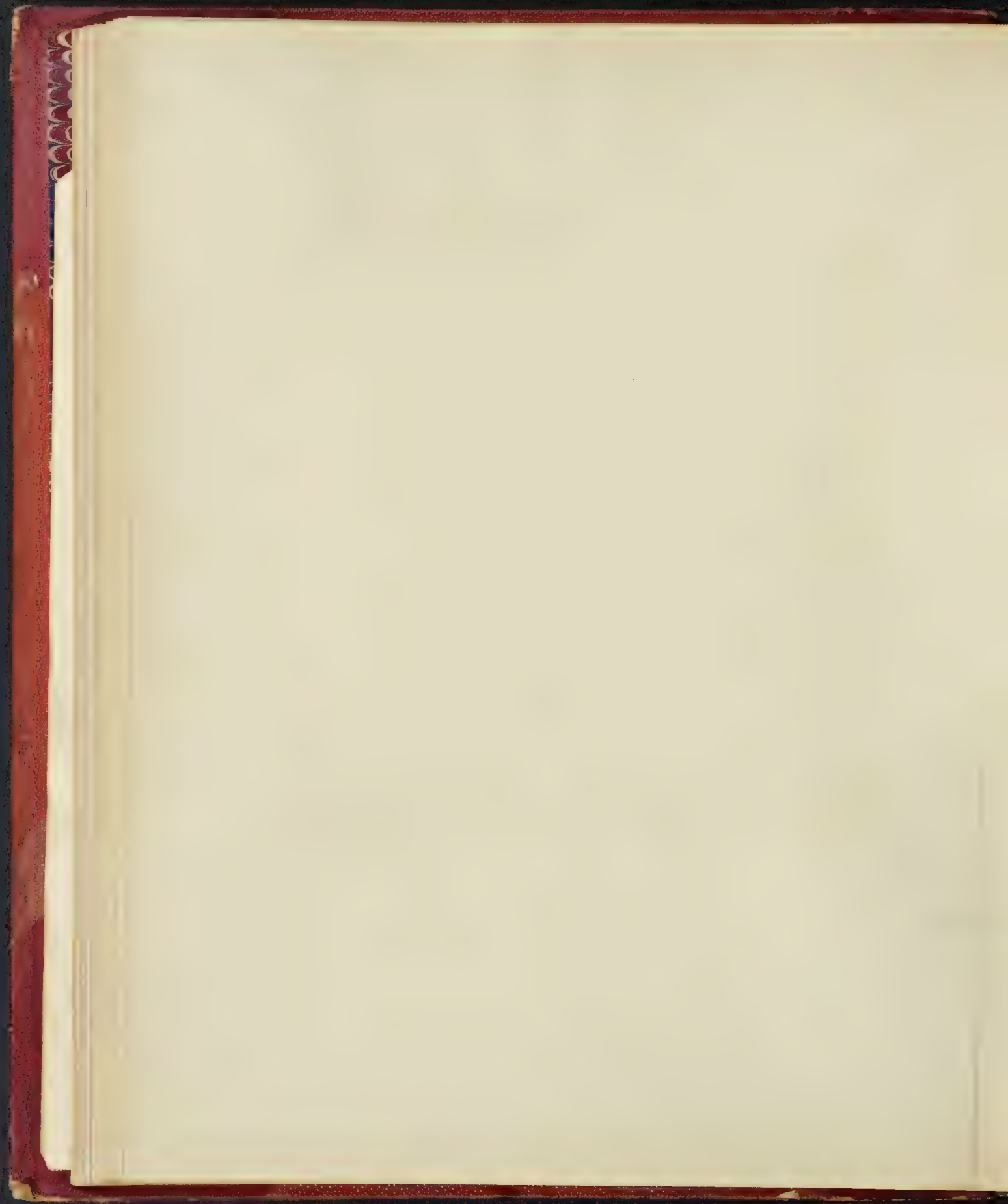


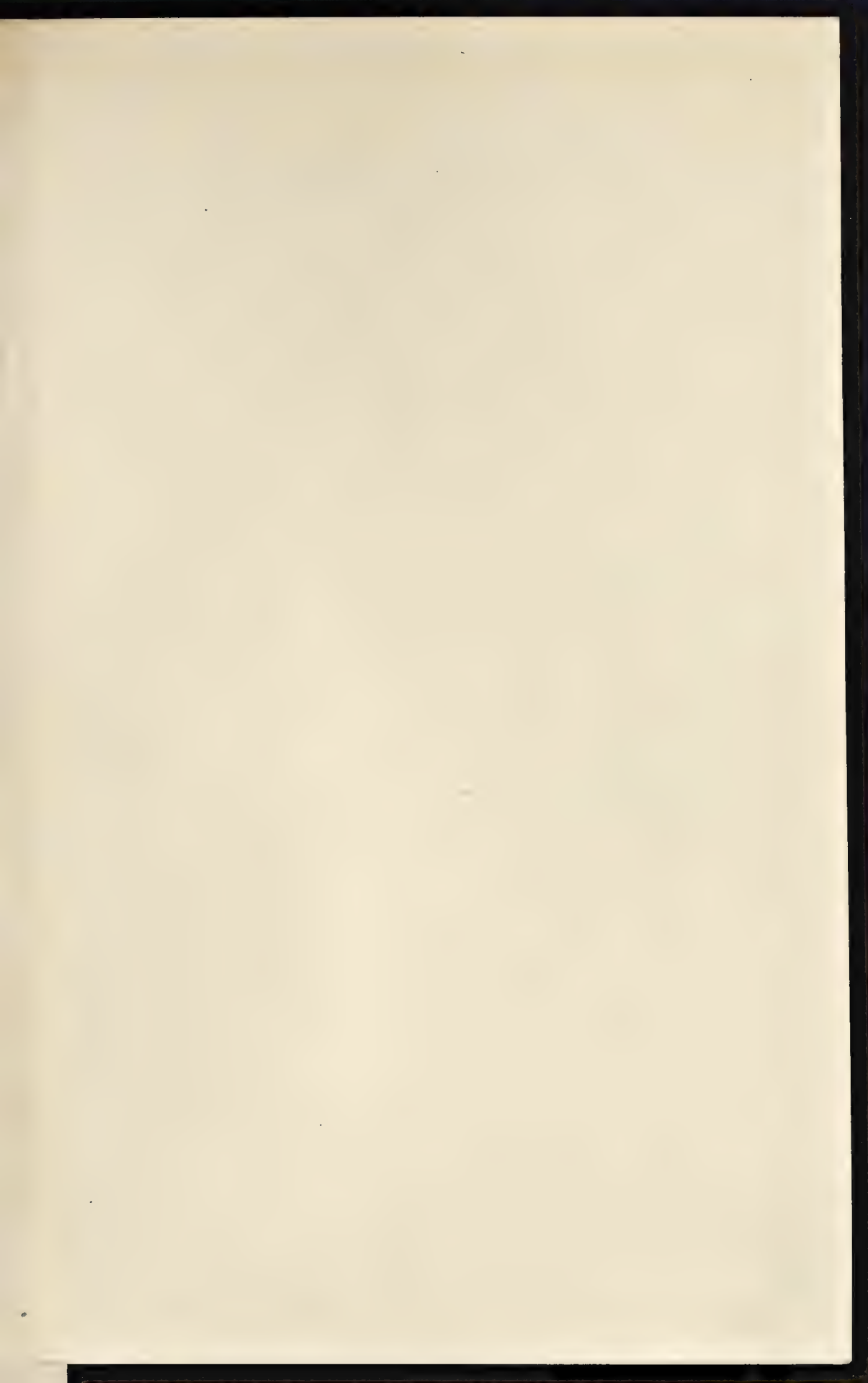


Navicula Rhomboidea, (to show beads,
(Bemis Lake — same frustule.)

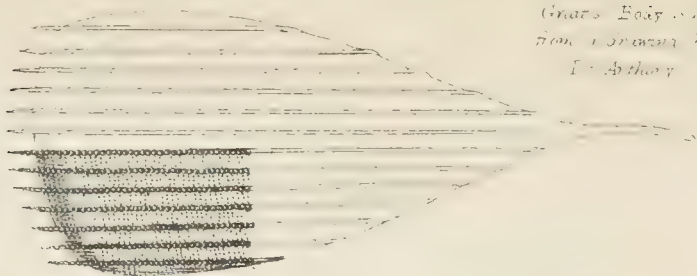
1700

Powell & Lealand's $\frac{1}{16}$ " m.
844

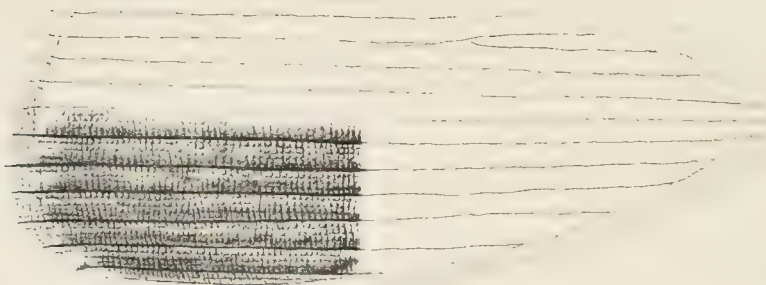




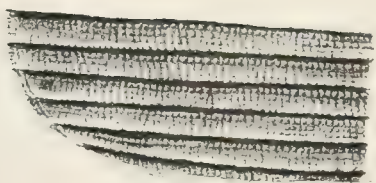
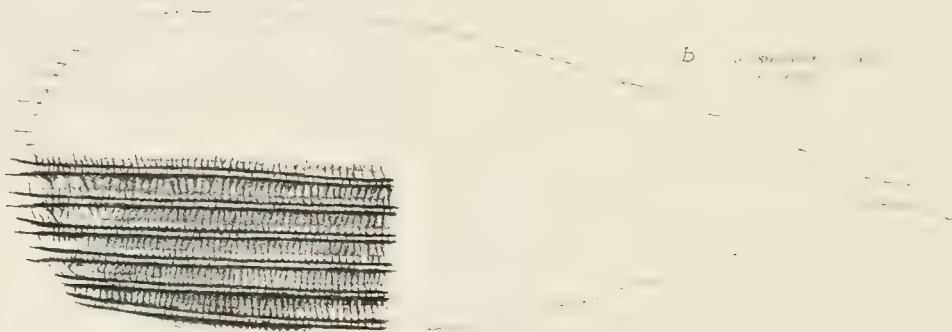
Grass Eddy
from a drawing by
F. Arthur

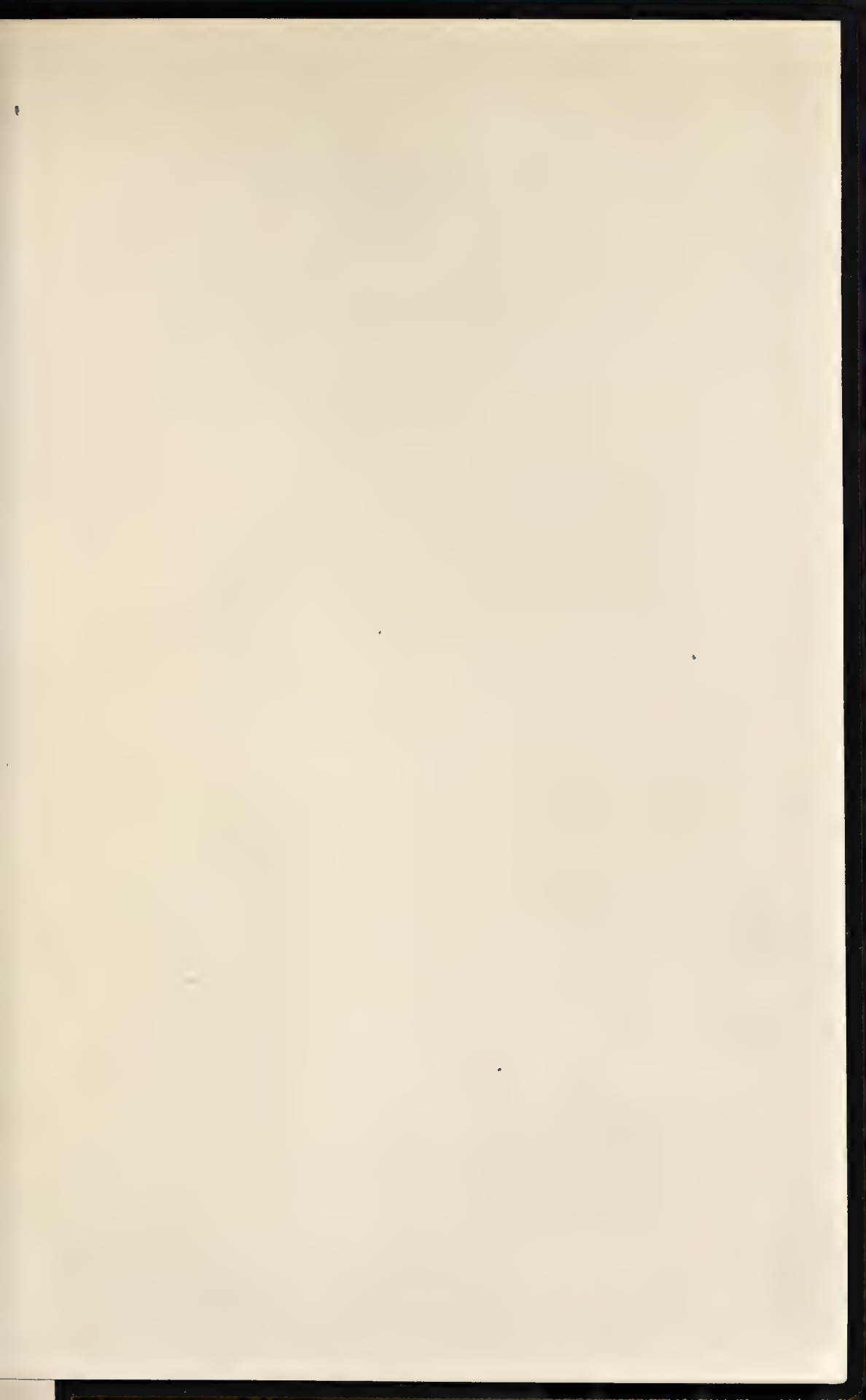


A. *Grass Eddy*
from a photograph by
Dr. Woodward, x1350

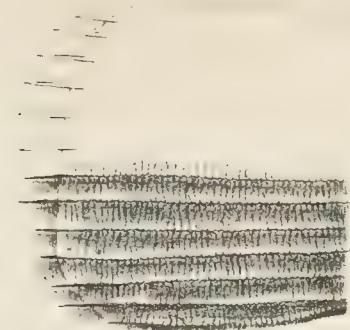


B. *Grass Eddy*





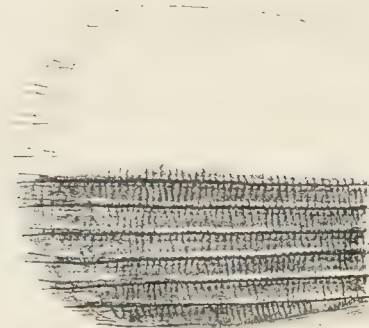
D. *Microscopical*
Journal
for the
Month of
June 1876



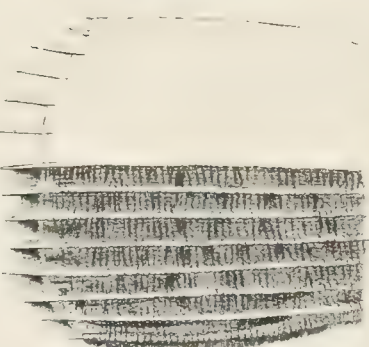
E. *do*



F. *do*



G. *do*



I.—*On the Markings of the Body-scale of the English Gnat and the American Mosquito.*

By Dr. J. J. WOODWARD, U. S. Army.

(Read before the ROYAL MICROSCOPICAL SOCIETY, May 3, 1876.)

PLATES CXXXIX. AND CXL.

My attention was first directed to the markings on the body-scales of the English gnat by a letter received last summer from Mr. John Mayall, jun., enclosing a mounted slide of these scales, and a photograph of a drawing of one of them by Dr. John Anthony, of Birmingham, representing the scale as *marked by longitudinal beaded ribs, having three uniform parallel rows of smaller beads in every interspace between two adjoining ribs.* (See Pl. CXXXIX.)

Mr. Mayall stated that Dr. Anthony had made the drawing to represent an appearance of the scale glimpsed by central light, but had not been able to show this appearance to him in the microscope as definitely as it appears in the drawing, and requested me to undertake to photograph the scale as seen under the microscope. This I did at such leisure hours as I was able to command during the latter part of last year, and in so doing arrived at results which may perhaps be of interest to some of your Fellows.

I at once observed the very great similarity between the scales of the English gnat and those of the American mosquito, with which I had been familiar for a number of years; a similarity which relates to all the details of surface markings, as well as to the size and general outlines of the scales. In the case of the mosquito, I had seen that the scales are crossed transversely by fine markings, probably ridge-like corrugations of the thin double membrane composing them, and that these transverse markings crossing the longitudinal ribs at regular intervals, gave to the latter a beaded appearance; but I had not believed that the transverse markings were also beaded. I must add that the ribs and transverse markings exist on both surfaces of the scale, though much more boldly on one than on the other, and that the longitudinal ribs of the opposite sides unite at the broad end of the scale, where they generally project as bristle-like appendages beyond the general contour.

My examination of the slide received from Mr. Mayall has led

me to the opinion that this description applies to the gnat scale as well as to the mosquito. Nevertheless, on examining a gnat scale, as requested by the donor of the slide, with the immersion $\frac{1}{16}$ th of Powell and Lealand, by central illumination, I succeeded, after some trying with the right-angled screws of the achromatic condenser, in obtaining, as I suppose, the very appearance Dr. Anthony's drawing is intended to represent, and the three parallel rows of minute intercostal beads started out suddenly into view between each pair of longitudinal ribs over the whole surface of the scale.

This appearance was so realistic that at first I inclined to the opinion that it represented truly the actual markings of the scale, and accordingly I endeavoured to photograph it as requested, with the objective named, by monochromatic sunlight, and after several failures succeeded in obtaining a fair representation of what I saw. I send herewith a print (marked A) from the resulting negative.

I have, however, since then been led to form the opinion that these clearly seen beads are a spurious appearance, produced by longitudinal diffraction lines, conditioned by the longitudinal ribs and parallel to them, which cross the true transverse markings at right angles, and thus give rise to the optical appearance of beads at the point of intersection; the whole series of phenomena being similar in character and origin to the diffraction phenomena observable in many diatoms, &c., as described by me in my "Note on the Markings of *Frustulia Saxonica*" in this Journal, December 1875, p. 274.

My chief reasons for this opinion in the present case are—firstly, that the longitudinal diffraction lines are clearly seen, both in the microscope illuminated by lamp or sunlight, and in the photographs (as, for example, in the print A) to extend into empty space beyond the contour of the scales almost as far as the ends of the bristles in which the parallel ribs terminate; and secondly, that they vary in number with varying obliquity of illumination, so that in the same scale two, three, four, or five rows of beads can be seen, and photographed at pleasure, in each intercostal space.

Since arriving at this conclusion I have had no difficulty in producing at will, either the beaded appearance, or that which I conceive to represent correctly the surface markings, on any scale I have tried, whether of the gnat or mosquito.

If the selected scale is illuminated with the light thrown perpendicularly to the transverse markings, by means of an Abraham's prism, the beaded ribs and smooth transverse markings will be clearly shown; and if now the stage be rotated so as to turn the long diameter of the scale more and more obliquely to the illuminating pencil, the spurious lines, and with them the beads, will start into view; the number of spurious lines, and consequently

the number of rows of beads, varying with the angle of the illuminating pencil. Or the true appearance may be produced by the achromatic condenser adjusted so that the light is either truly central, or slightly oblique in the direction of the length of the scale; and then a very moderate degree of obliquity in the illumination transversely to the scale, obtained by means of the right-angled screws of the condenser, will bring out the rows of beads, varying in number as in the former case, in accordance with the degree of obliquity attained.

I submit these results without further comment at the present time, with a few additional photographs intended to represent some of the chief appearances obtained. Two of these pictures, in addition to that mentioned above, are from the slide of gnat scales sent by Mr. Mayall, and are taken with the immersion $\frac{1}{16}$ th of Powell and Lealand; the others represent a mosquito scale as seen with an immersion $\frac{1}{18}$ th, constructed for the Museum by Mr. Tolles, of Boston. I selected for this series a different lens from that used for the gnat scales to show that the diffraction appearances discussed in this paper result from the optical conditions under which the scales are viewed, and not from any peculiarity in the objectives of any particular maker.

In conclusion, I would refer those who desire preliminary information as to the character and distribution of the gnat scales to the paper by Mr. Jabez Hogg, "On Gnat Scales," in this Journal for October, 1871, p. 192; or to his work on the Microscope, the first edition of which was published in 1854. The description there given of the various forms of gnat scales, and of their distribution on the insect, is very nearly accurate for the mosquito also.

List of Photographs.

- A.—Gnat scale, showing three rows of intercostal beads. Magnified 1350 diameters by Powell and Lealand's immersion $\frac{1}{16}$ th. (Neg. 771.) See Pl. CXXXIX., Fig. A.
- B.—A smaller gnat scale, showing smooth transverse markings. Magnified 1500 diameters; same objective. Achromatic condenser; central light. (Neg. 781.) See id., Fig. B.
- C.—The same scale, with same objective and power, but moderate obliquity of illumination obtained by means of the right-angled screws of the condenser. (Neg. 782.) See id., Fig. C.
- D.—Mosquito scale, showing smooth transverse markings. Magnified 1350 diameters by an immersion $\frac{1}{18}$ th of Tolles. Achromatic condenser; nearly central light. (Neg. 765.) See Pl. CXL., Fig. D.
- E.—Same scale, same objective, but light oblique laterally as well as transversely, showing two rows of beads in each intercostal space. 1350 diameters. (Neg. 768.) See id., Fig. E.
- F.—Same scale, &c., showing three rows of beads in each intercostal space. 1300 diameters. (Neg. 778.) See id., Fig. F.
- G.—Same scale, &c., showing four rows of beads in each intercostal space. 1350 diameters. (Neg. 766.) See id., Fig. G.

Note by John Anthony, M.D.

Having read Dr. Woodward's paper on the gnat and mosquito scales, and looked carefully at the set of photographs in illustration, which that gentleman has had the kind courtesy to forward to me, I can come to no other conclusion but that what I have hitherto regarded as real bead markings on the membrane in the intercostal spaces on the scales from the body of the gnat are really and truly spurious images, or, in the words of Dr. Woodward, "diffraction appearances."

Some two years ago, in the examination of a large number of gnat scales, principally with the fine $\frac{1}{8}$ th and $\frac{1}{16}$ th objectives of Messrs. Powell and Lealand, such results were obtained that I thought I had found in the scale from the *body* of the gnat an excellent test for the "definition" of high-power objectives, inasmuch as there seemed, with moderately oblique and well-corrected light, what appeared to me triple rows of clearly defined beads between the beaded longitudinal ribs of the scale; and, as the same appearances of beads were always manifest, and as those beads always seemed to come out clearer when viewed with objectives of well-known excellence, I trust to be pardoned for believing that what I saw were not only real appearances, but that such objects as the gnat scales might be of the greatest service to the microscopist as tests for the defining qualities of high-power objectives. Under such impression I made a careful drawing of the markings on the gnat's scale under the most favourable conditions, and that drawing I copied by means of photography; the photograph would have been made directly from the scale of the gnat itself, but I had no heliostat. These photographic copies of the drawing have gradually passed into the hands of one or other of my microscopical friends until the specimen forwarded with this paper is the only one left to me. However, I have the negative, and if possible impressions shall be printed for distribution among the members present at the next meeting of the Society.* (Pl. CXXXIX.)

Taking the E, F, and G photographs of Dr. Woodward to be the most characteristic, inasmuch as they show respectively two, three, and four rows of beads as seeming to exist upon the same scale under different conditions of illumination, I think one can only look upon my drawing as a representation of very clearly seen spurious beads. Of course it is not very flattering to one's *amour propre* to have it shown so convincingly that one has taken the shadow for the substance; but I am assured that I shall have erred in good company, inasmuch as the analysis of these diffraction images will strike at the root of a vast number of descriptions of

* Some were sent by Dr. Anthony to the meeting.

quasi beaded tissue seen in all sorts of objects examined with high-power lenses.

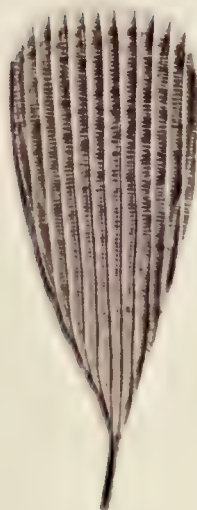
This brings me naturally to the observation that I think microscopists, who are not too proud to learn, owe to Dr. Woodward a debt of gratitude for the trouble he has taken, and the skill he has displayed, in teaching us the precautions we ought to take in high-power investigations to distinguish between the false and the true. I have worked long enough at the microscope to feel that as a rule one ought, like the late Lord Eldon, to "doubt" everything; and have often amused myself in producing, on well-known diatoms, a series of permutations of "diffraction phenomena," and therefore can appreciate most fully the truthful excellence of Dr. Woodward's article and illustrations in the December number of the '*Microscopical Journal*.' I regard these papers on spurious appearances as among the most valuable contributions to microscopical literature. Dr. Woodward points out that detail, however clearly seen upon a scale, may be more than suspected of being unreal if it seems not to be confined to the limits of the scale or shell itself, but to "pass off into space." A question arises as to how you are to deal with the appearances, such as a fairly careful observer might get, and such as I myself observed on the gnat's scale, where there was no projection of the image into space; a phenomenon with which, as I stated, I am very familiar. The only suspicious point noticed was an apparent alteration in the character of the detail on revolution of the object, but the employment of light more or less oblique has in most cases, and particularly in very diaphanous objects, accustomed one to look at certain scales always in the same position with respect to the plane of the illumination as being "best seen"; and it is to be feared that very many of us, in our employment of the microscope, are apt to be led away by beauty of image.

It appears to be clear that no perfection of "condenser," and no superior quality in the objective, can save us from acquiring erroneous impressions of what we see in the microscope, if we have not a very distinct notion of the "pitfalls" which await us in the shape of diffraction images. Dr. Woodward evidently has grasped this difficult subject with a master hand; he has used photography as a witness—which to me is most satisfactory; he has given us a most valuable lesson, and I for one beg to thank him for it.

WASHWOOD HEATH, BIRMINGHAM,
April 3, 1876.



from a drawing
English Gnat Scale, ¹ By R. Anthony.



1861
Mosquito Scale.

1861

Tollis's 78' mi
760



Mosquito Scale.

1857

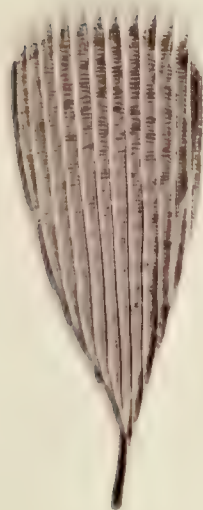
Tolles's $\frac{1}{8}$ in.
'68



Mosquito Scale.

1309

Follen's $\frac{1}{8}$ in.
778



NEW YORK

Mosquito Scale,

1850

Tolles's $\frac{1}{8}$ in.
1766



English Gnat Scales.

1500

*Powell & Lealand's 76' m.
787*



English Gnat Scale.
Another view of the same.

1500

Powell & Lealand 5 $\frac{1}{16}$ in.
752



Same scale of English brat

1350

Powell & Co. 15 1/16" in.
77'













THE MASTER OF PHOTO-MICROGRAPHY

270. WOODWARD, J(OSEPH) J(ANVIER). Photo-micrographs of the Mosquito, &c. Washington(?): Army Medical Museum, 1872 \$4000.00

Small folio, orig. half morocco, cloth sides with title printed in gilt on front cover. With 4 printed leaves of text and 34 mounted albumen micro-photographs (160 x 160 mm), each on a printed card mount with gold border and combined manuscript and printed caption. In very fine condition throughout.

A rare series of very beautiful micro-photographs of insects, e.g. the mosquito, bed bug, head louse, dog louse, soldier beetle, beetle, parasite fly, wine cellar fly, water bug, etc. These images are approximately 6 inches on a side and are of startling beauty; though they were originally made in the aid of science, we see them today as art. Woodward was the foremost practitioner of his craft . . . "the foremost place among those who have aided in this progress will readily be conceded to Lieutenant-Colonel J. J. Woodward, a distinguished surgeon in the United States Army, whose photographs of difficult test-diatoms and of artificially ruled lines will long serve as models which less accomplished microscopists can scarcely hope to equal . . ." (Sternberg, *Photomicrographs*, p 2). The D.A.B. states that Woodward attained an international reputation in photo-micrography. This volume is very rare; there were probably no more than 25 and at most 50 copies prepared.

Very good copy.

“There were two further great works of chromolithography produced during the ‘fifties’, and one in the ‘sixties’, all by J. B. Waring (1823-75), an architect, a Swedenborgian, and in his own later estimation, a prophet. The larger (indeed one of the largest chromolitho books ever produced) was *The Arts connected with architecture . . .* published in 1858 by Vincent Brooks. The page size was slightly smaller than Lewis Gruner’s *Specimens of ornamental art*. It starts with a fine ornamental colored title-page and contains 41 plates with accompanying text. Waring drew all the plates himself and Vincent Brooks lithographed them. Some of the plates, e.g. of marble inlays, are in only one or two colours, like plates in *The Grammar of Ornament*, but there are several plates of stained glass windows and frescoes which were more ambitious (since they represent depth, shadows and perspective as well as design and colour) and were perhaps the finest chromolithographed plates yet produced in Britain.” — McLean, *Vict. Book Design*, pp 124-5.

THE FIRST WEBSTER’S DICTIONARY

268. WEBSTER, NOAH. An American dictionary of the English language. New York: S. Converse, 1828
\$2000.00

2 vols in one. Lg. 4to, new marbled boards, calf spine, orig. 4-1/2 inches wide morocco lettering piece preserved indicating that this copy was originally bound as